AUSTRALIAN RESOURCES AND ENVIRONMENTAL ASSESSMENT (AREA) MODEL

A study by the Department of Science and the Environment in consultation with Commonwealth departments and agencies

A PRELIMINARY ACCOUNT OF AUSTRALIAN AGRICULTURE IN A GLOBAL ECONOMIC CONTEXT

by

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The views expressed in this paper do not necessarily reflect the opinions of the Department of Science and the Environment, nor of the Australian Government.

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ABSTRACT

Global research projects in recent years have recognised the fundamental nature of food policy in the changing pattern of international relations. Some projects have focussed on this area of investigation, others like the study described in this paper have worked from the premise that food problems are central to the so-called global *problematique*. Thus in seeking debate on the content of work-in-progress to develop a World-Australia economic model, we could not improve on starting this process with the Australian Agricultural Economics Society.

Accordingly, we have attempted to draw out the agricultural content of our work to extend an existing regional model of the world economic system. Completed agriculture-based case studies using the existing model are described to provide a context for proposed issue-based case studies dealing with food and energy problems relative to resource depletion constraints and considerations of environmental feasibility in Australia.

CONTENTS

LIST OF FIGURES

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1. INTRODUCTION

While in its infancy, regional modelling of the global economy may be never more than a branch of political economy - at present an unruly one.[1] To-date, most major global research projects have addressed food policy issues. One such study has focussed on international relations in agriculture,[2] while another currently in progress is linking existing national agricultural models by means of an international trade-in-food mechanism.[3] The model we consider here was built up from the premise that at the global scale the problem of food production and distribution was fundamental. Since the model attempts to describe and link the dynamics of total economies, it offers a capability to examine global and regional food policy issues in the context of the world economic system as a whole.

The existing model referred to herein was developed by the Systems Analysis Research Unit of the UK Department of the Environment and is termed SARUM. The project to extend this model for Australian Resources and Environmental Assessment has the acronym AREA- the resulting computer model is referred to as AREAM. Considerable collaboration and consultation with national and international agencies has been sought and obtained in conducting the AREA Project.

An overview of AREAM is followed by an outline of the agriculture sectors of the model. Four case studies in food policy examined by the SARU model to-date, are briefly described: (1) substitution of high-protein vegetable food-stuffs by single-cell protein; (2) the Australian food export situation in the context of world food projections by the OECD's global research project, Interfutures; (3) abundant food for 12 thousand million people by 2100 AD; (4) subsistence living for 12 thousand million people. Issues to be considered in a case study in food and energy in the Australian, New Zealand and neighbouring regions completes the paper.

2. OVERVIEW OF THE MODEL

Detailed descriptions of SARUM are available elsewhere.[4] Briefly, the model is a dynamic simulation of the global economy. Based on neo-classical principles it is structured to recognise the many factors that inhibit instantaneous clearing of markets, rather than adjusting prices to equilibrate supply and demand in each period. Current work is adding Australia and New Zealand as two separate regions to those already existing for the ASEAN and other South East Asia, Japan, China, India-Pakistan, Western Europe, North America, Eastern Europe, Latin America, Middle East and North Africa and sub-Sahara Africa. Within each region there are interrelated sectors for natural products, irrigation supply, land development, fertilizers, food, energy, minerals, other manufactures, machinery, construction and services. Population projections for each region are exogenous and taken as the UN median projections. In current work to develop the Australian and New Zealand regions population growth within and migration with respect to these regions will be modelled as a further endogenous sector. Migration is being modelled using a mechanism similar to that developed for trade interactions among the regions. A matrix of trade biases for each commodity traded accounts for many of the factors inhibiting the functioning of free markets. While aid can flow from one region to another in the model there is no attempt to model the international money markets.

The impact on the Australian environment of changing economic conditions and demographic change world-wide is also being modelled. However, at this stage, it is envisaged that this sector will be constructed to post-process these impacts; ie., to ignore the reverse impacts of environmental policies on the Australian economy.[5]

3. AGRICULTURAL SECTORS

Again it is not intended to give a full description of the agricultural sectors and reference should be made to earlier papers and SARU reports.[6] From what has been stated above, there are five sectors which form the structure of agricultural activities in the model. These are food, fertilizers, irrigation supply, land development and natural products. However, agricultural activities will also draw on machinery and labour sectors, the labour requirement being calculated from the population sector. It must be stated at the outset that the sectors which make up the present agricultural activity is by no means the only configuration and in fact the SARU team have used a structure which replaced food production with fruit and vegetables, vegetable processing, cereals and roots, livestock production and livestock processing.

Production in the industrial sectors of the model are a function of capital and labour and inputs into these sectors are in general proportional to outputs. However in the agricultural sectors, modelling the growing and harvesting of crops can not be satisfactorily represented in this way. The yield from a sector depends upon the level of inputs per unit area, and the area under cultivation. The harvesting capacity depends upon the capital and labour. A farmer will endeavour to choose his factors of production so that his harvesting capacity is approximately equal to his yield. No attempt is made to incorporate the annual cycle into the model of the agricultural sectors. Thus, the concept of complementary factors of production are introduced. The harvesting capacity function resembles the industrial production function in the model which is a Cobb-Douglas function of capital and labour. The yield production function is itself a function of fertilizer and pesticide inputs, irrigation and arable land.

Prices of agricultural commodities are determined in the same way as for other commodities in the model. The cost factor includes the costs of fertilizer and irrigation together with the cost of renting land. The allocation of factors of production to the agricultural sectors is more complicated because consideration has to be given to the allocation of land, fertilizer and irrigation, as well as capital and labour. In allocating labour, we assume that the desired condition is approximated by equating harvesting capacity with yield.

A mechanism is incorporated for allocating the available arable land between the crop-producing sectors based on the average return to land, thus assuming that the farmer will devote more of his land area to that crop giving the higher return. The notional rent is in fact the smoothed average return to land. Once present land has been allocated, the development of new land must be modelled. A farmers decision to obtain additional land is assumed to be based on a comparison of the return from land with the return by investing elsewhere.

Technology can improve crop production and this is modelled by changing the parameters of the response exogenously. Technological growth is allowed to affect the yield production by affecting the response function to the fertilizer and irrigation inputs.

In the present version of the model, there is a single food sector, whose output is expressed in cereal equivalent. The supply requirement for food is generated by the existence of the purchasing power to create effective demand. The model relates expenditure on food to income and price, and the physical flows derived from these economic variables, subject to an upper limit of food energy intake. Pressures on resources are translated into price increases, which may then effect demand. There is no concept of a gap

between domestic supply and demand being met by imports. The model does not require the assumption of fixed or pre-determined fractions of demand being met from abroad and it does not require an assumption of uniform prices in world trade.

4. AGRICULTURE-BASED CASE STUDIES

Several agriculture-based case studies have already been evaluated using the existing global model. Some of these have been undertaken as in-house studies while others have been commissioned by government authorities or international organisations.[7] Examples of case studies in this category include:

- substitution of high-protein vegetable foodstuffs by single-cell protein;
- the Australian food situation in the context of world food projections by the OECD's global research project, Interfutures;
- abundant food for 12 thousand million by 2100 AD;
- subsistence for 12 thousand million.

4.1 Single-Cell Protein

The model has been developed to permit the introduction or substitution of new sectors for existing or depleting sectors. This take-over of new technologies and processes is affected by a *seed* sector mechanism. The *seed* sector when activated begins by generating a small proportion of the total production of a commodity and as such it does not yield profits. To reduce the effects of depreciation of capital the sector is allocated a *subsidy*. Its labour force is frozen. These subsidies are subtracted from the total expenditure (sum of value added) of the sector in which the seed sector functions. Application of this substitution

Figure 1

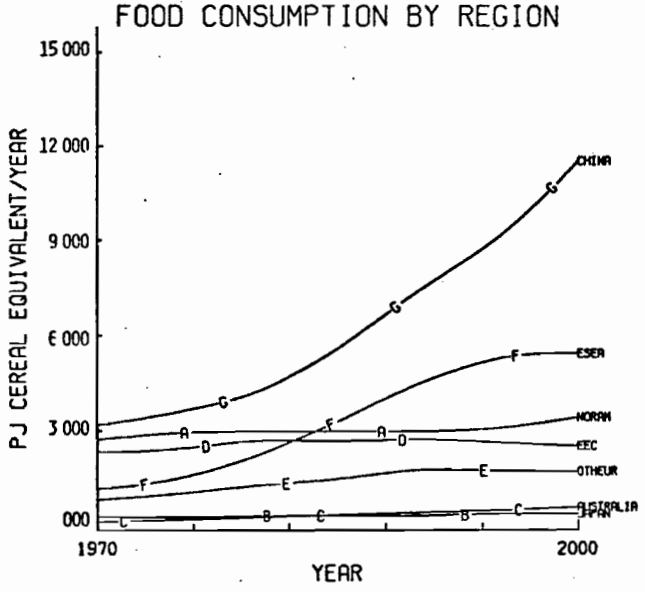


Figure 2

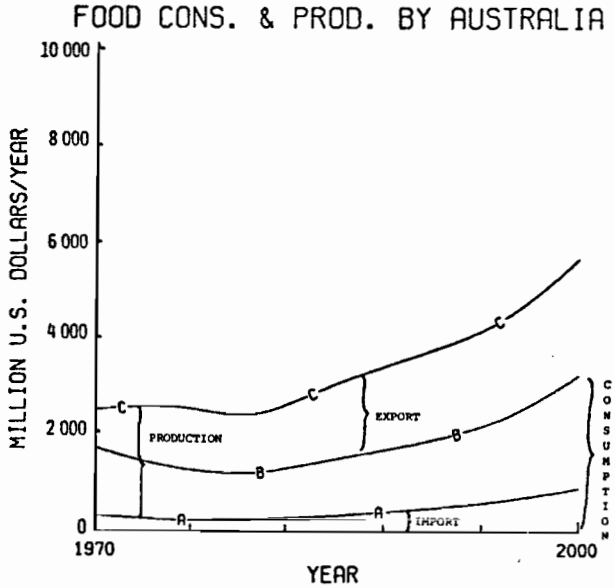


Figure 3

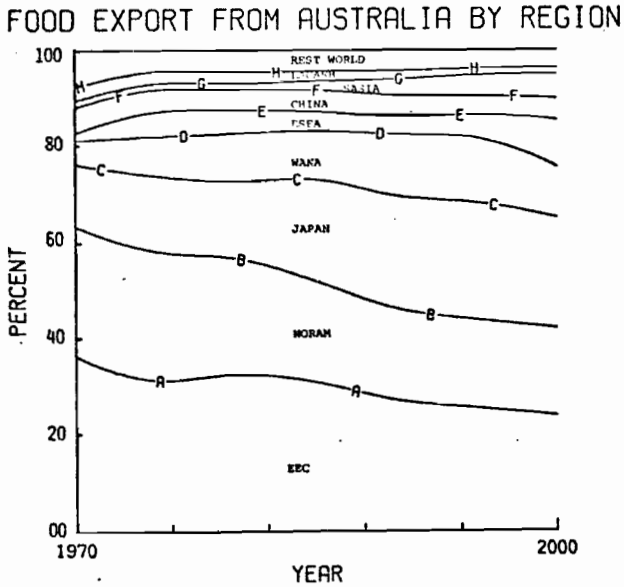
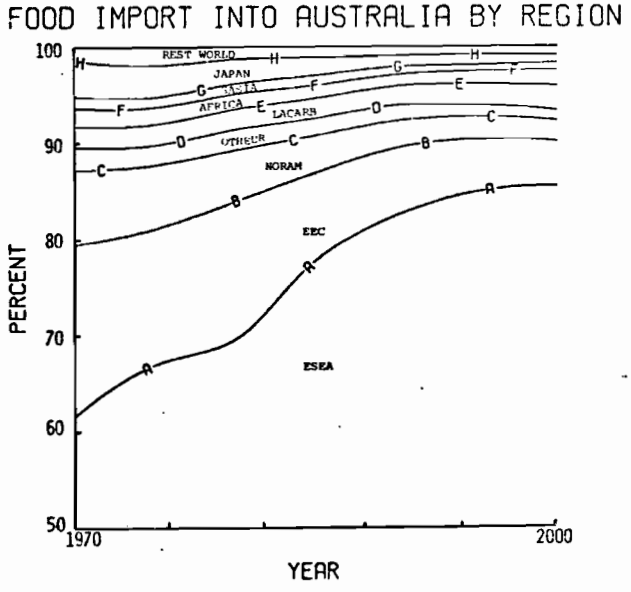


Figure 4



concept has been directed in one instance to the production of unconventional foodstuffs, in particular the substitution of single-cell protein (SCP) for high-protein vegetable feedstuffs, by industrial production. Three SCP production processes are modelled as independent sectors manufacturing products which are substitutable for the high-protein feeds required by the livestock production sector. Substitution was allowed by deferring a second livestock production sector which did not require the inputs of processed vegetable products and processed animal products (fishmeal), but instead, required the appropriate quantity of SCP.

4.2 Preliminary Australian Food Projections in a World Context

The OECD's global research project, Interfutures, was undertaken to determine the economic, political and social climate necessary for optimal economic growth and increased standard of living in both the developed (the north) and the developing (south) countries. A number of case studies were evaluated within scenarios of changes in political and trade alignments.[8] In relation to food distribution problems, the view is emerging that food diplomacy will play a role in national and international security in the next 30 years and may even be used to off-set or balance other resource diplomacy initiatives.[9] Although a number of studies carried out recently have shown that there is sufficient food in the world for all our needs, it is the maldistribution of this food pool which will cause hunger in certain regions. An identification of the areas of most need and the increase in the supply to meet those needs have been evaluated using the model.

For a scenario based on extrapolation of past conditions, the demand by region for food from home grown sources is shown in Figure 1. The levelling-off of demands particularly in the EEC and Australia, merely indicates that the pre-determined saturation level in food intake is being

reached. In Japan on the other hand, this is due to a saturation in the level of land available for agriculture. Regions like China and East and South East Asia (ESEA) continue to increase their demand. In both cases this is as a result of increased population, but in China's case it is also attributable to an increased consumption per head. In response to this increased demand in other regions, Australia's exports increase as shown in Figure 2. The markets to which these exports are directed are shown in Figure 3. Attention is drawn to the move away from the traditional markets of EEC (from 36 to 27 percent in the 30 years to 2000) and North America (from 27 to 18 percent). There is an increase in the Japanese imports from Australia from 13 to 23 percent, for Asia from 3 to 15 percent and for the Middle East from 3 to 11 percent. The same movement away from traditional markets is seen in Figure 4, where the ESEA region supplies Australia with 85 percent of its imports by the year 2000.

4.3 Agricultural Abundance

In a *food abundance* scenario[10], world crop production potential is increased to 14 times the 1970 level, industrial productivity in all regions converge to 50 percent above the 1970 USA level and the UN median population projections are not exceeded - ie., world population stabilizes at a level of 12 thousand million by about 2100. As a result of these assumptions there is a 20-fold increase in world food trade by the year 2100 and on a regional basis East and South East Asia becomes the main food importing region. This is as a result of rising per capita incomes and continuing population growth, as indicated earlier. There is also a switch in the exporters where Latin America and later the USSR, assume a major role with a decline in dominance of North America (Figure 5). Although the emergence of the USSR as a major exporter may appear surprising by this time it is shown to have the lowest population density per hectare of potential arable land globally excepting Australia.

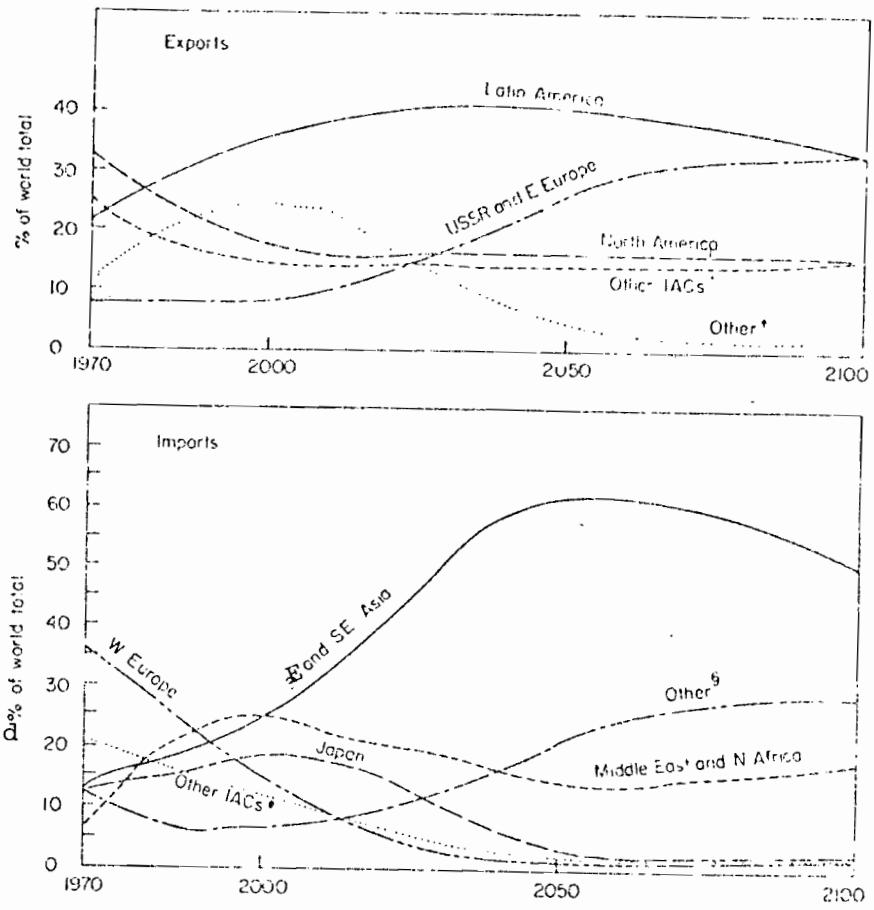


Figure 5. Future pattern of food trade in world abundance scenario.*

*Excludes trade between USA and Canada, and between the EEC and the rest of Western Europe.
†Other industrially advanced countries (IACs): Australia, New Zealand, South Africa, Western Europe, and Japan.
‡ Other: Middle East, Africa, East and Southeast Asia, and China.
§Other: Africa (south of Sahara), and China.
◊Other IACs: USSR and Eastern Europe, Australia, New Zealand, South Africa, North America.

4.4 Agricultural Adversity

Under the *agricultural adversity* scenario[11] the optimistic view that there would be a great increase in potential food production is severely curtailed to allow just enough food to be produced to provide a nutritionally adequate diet for 12 thousand million people, given an equitable distribution of food. This implies a global production four times the 1970 level. As a result of this cut back, in the year 2000, food production in East and South East Asia is three quarters of the level reached in the abundance scenario. Production in the industrialized regions is 7 percent higher, and their extra exports to the poor regions make up for about one quarter of the shortfall in production. This is with the very favourable assumptions about economic progress in the rest of the region's economy,

which underlies the abundance scenario. To test whether adversity in one region is more or less detrimental than adversity in all regions, a case study was run in which only East and South East Asia experienced the agricultural adversity and world abundance was retained in all other regions. In the year 2000, imports compensated for one third of the region's shortfall, compared with one sixth in the general agricultural adversity case. However, by 2010, this fraction increases to two thirds as imports are available more cheaply. Thus availability of lower priced supplies from other regions is of substantial benefit to a densely populated region facing severe environmental constraints in agriculture.

Some possible case studies to mitigate the effects of adversity were also run with another model configuration (recognising the differences between animal and vegetable food sources) to measure possible effects. The first was a change introduced gradually over 30 years, to reduce the industrialised countries per capita demand for world crop production by 40 percent, this level still being double that of the poor regions in 1970. The resultant effect was an increase in the general consumption and per capita food intake in the poor regions but the gain falls far short of closing the gap. In the second, possibilities of substitution for feedgrains were introduced and these had a negligible effect on the poor regions owing to high trade biases in livestock trade.

To explore possible consequences of free trade, a case study was run in which all trade biases between regions were eliminated over 30 years. An important result of this case study is that liberalisation does not benefit everyone when compared with the world abundance scenario. Using the general index of consumption per capita as the criterion, the USSR and Eastern Europe and Australia, New Zealand and South Africa (treated as one region) lose. The USA breaks

even, and the other industrialised regions gain in varying degrees. Among the industrially less developed, Latin America, China and Africa lose, whereas East and South East Asia and the Middle East are the beneficaries.

This analysis of the food abundance and adversity scenarios was recently reported in *Food Policy* and concludes that growth in food trade rests heavily on growing industrial incomes. If GDP growth in poor regions lags, the rapid growth of food trade in the abundance scenario does not materialize, and food consumption per capita remains low in Asia and Africa.

5. PROPOSED ISSUE-BASED CASE STUDIES

In designing experiments for evaluation by the model, SARU's initial thrust was toward the analysis of food production and distribution problems since the problem of feeding a growing global population was viewed as more fundamental than ensuring *adequate* energy supplies or maintaining a *sufficient* supply of minerals. Australia is situated in a region where there are two extremes of food intake. The people of underfed Asian countries typify those at one end of the spectrum while Australians are more concerned with heart disease from over-eating than malnutrition and starvation.

There have been claims made in press reports that Australia could feed at least 40 million people in developing countries by the year 2000.[12] The production and availability of food depends on four main factors - soil, climate, population and technology. However the way these factors interact is greatly influenced by policy so that to a great extent food production depends on political circumstances.

Focussing, for the moment, on the physical constraints we note that soil can be broken down into sub-factors for land and water. Of the total land area of 768 million hectares, rural holdings made up 500 million in 1977, some 65%. However, only 42 million hectares (5.5% of the total land area or 8.4% of the rural holding) was cropped or sewn. Estimates have been made of potentially arable land of 126 million hectares.[13] This estimate is always changing as a result of water availability and climatic variations. Another influence on this change is the arable land which is taken out of the pool by salination of the soil. The AREA model will be able to explore the effects of irrigation and land development within a dynamic interacting structure. Possible new contenders for land, such as the production of bio-fuels through large scale energy farming, will also be investigated.

Only 1.5 million hectares of land are irrigated in Australia; ie., 3.5% of the cropped and sewn land. Thus most of the agricultural activity is dry-land farming and as a consequence is subject to climatic variation. Some of this variation is imposed on us through changes in global circulation and deforestation. In the Australian situation these climatic perturbations, although having harmful economic effects, do not impinge on the peoples eating habits. However, our food exports influence the food stability situation internationally. Poor harvests can have an adverse impact on world supplies. Accordingly food security planning at the international level is beginning to account for extremes in climate rather than average conditions. Buffer stock and related production policies under these conditions can be explored by the model.

The role of technology in improving yields through plant breeding and increased response to chemical inputs will be examined in relation to its indirect impact on agricultural production. For example, through a response from our Asian neighbours for greater food imports as a result of increased

incomes generated by the transfer of technology from the industrialized nations. Recent case studies[14] show this increase in incomes and the resulting demand for imports in food. Creating this demand will necessitate the increase in industrial activity in developing countries. This industrial growth pattern can be manipulated through the transfer of technology and various growth patterns will be evaluated to measure these effects on trade. Technology will then be applied to improve the developed nations yields from agriculture to see if they can supply the Asian demands for food. Environmental side effects from the ever increasing use of chemical inputs and irrigation, to achieve increased yields, will be monitored through the environment sector.

International trade in food will play a major role in the removal of disparities in food intake per head across the world. One of the major inhibitors to the removal of this food disparity is the ability to pay. Aid to the developing countries will have limited effect on the redistribution of incomes internationally. Each country or region will have to be looked at separately in attempts to address the problems of food security. Factors that will be considered include:

- the expansion of exports by developing nations to purchase food imports;
- the opposite policy of food self-sufficiency creating food insecurity as a result of periodic climatic variations;
- the application of aid in developing countries to the procurement of consumable as opposed to investment in industrial capacity;
- the reliance on one major exporter of food (in 1973 North America supplied 91 million tonnes of grain with Australia supplying 6 million for international grain trade - the only two regions that were net exporters in that year);

. the size and distribution of regional buffer stocks (recent press reports on FAO plans for world food resources instigated in 1974, indicate that there are still some difficulties which have to be overcome).

For the world's population to be fed adequately new and improved practices would have to be adopted: the elimination of waste in production, transport and storage, and the utilization of grazing wild animals and plants on a controlled basis. Live-stock feed in developed countries (which amounted to two fifths of world cereals in 1970) is overwhelmingly the biggest factor increasing the per capita demand on crop production resources. Reduced grain demand by industrialized countries may come about not only through lower consumption of livestock products, but also through the use of livestock feeds that do not compete with food crops for arable land ie., waste products from agriculture and industrial by-products. Substitutes for livestock products have been mentioned earlier in relation to single-cell protein but a recent report from the United States has warned of the impending threat of artificial cheese to dairy farmers, similar to the margarine/butter substitution. In the main these issues could be evaluated using the model but some sector changes may have to be made to look at differences in livestock and cereal food supplies separately.

One area of study to be undertaken which is of considerable current interest will examine the implications of a customs union between Australia and New Zealand (UANE). As is well known, a recent poll conducted by a New Zealand newspaper indicated that nearly 70 percent of respondents were in favour of a union - interpreted subsequently as political union and not just a customs and economic union.[15] An opinion is expressed by New Zealand agricultural scientists and others that New Zealand could supply all of

Australia's protein requirements and thus free Australian land for growing cereals either for food or for energy. With the model we will be able to explore some of the consequences of such a union by eliminating all trade *biases* between the two countries as well as limiting imports into the UANZ region of commodities which can be produced by either country, particularly agricultural products. Similar *unions* could be explored with ASEAN and other South-East Asian countries.

6. CONCLUSIONS

Noting that a number of global research projects have addressed international food policy issues, we have sought to demonstrate the potential of work-in-progress in Australia to examine food and energy issues and, as these effect Australia, to account for the environmental feasibility of development options. While the AREA project focusses on the impact of human activities, such as harvesting activity and energy production, on the Australian environment and the constraints caused by the depletion of natural resources, the model which it produces may be used to explore a wide range of questions affecting the Australian economy within the context of the world economic system.

At this stage, the AREA project aims only to produce exploratory results. In meeting this aim an assessment is being made of the utility of conducting this form of policy analysis within government. Meetings of this kind are viewed as an important part of this assessment process. If this leads to detailed critical analysis and for involvement in the project through application of the model by policy analysts the quality of this assessment process is assured.

FOOTNOTES

1. From a DOE commissioned critique of SARUM-1975 by P.M. McPherson, Professor Systems Science, City University, London.

2. H. Linnemann, *MOIRA - A Model of International Relations in Agriculture*, North-Holland, Amsterdam, 1976.

3. Within one of their four main areas of research, IIASA is conducting an international food-in-trade model to link with individual national models of agricultural systems. Work is in progress in Australia among agricultural economists to develop a national model for this project.

4. Descriptions of the model in the context of its application to Australia and New Zealand case studies can be found in a number of the AREA Project papers. The most comprehensive mathematical description of the current structure of the model is to be found in *SARUM Handbook*, UK Department's of the Environment, Transport, Mimeograph, London, October 1978. The most comprehensive description of the structure and application of the model is to be found in *SARUM 76 Global Modelling Project*, Systems Analysis Research Unit, United Kingdom Departments of the Environment and Transport, HMSO, London, 1977.

5. This assumption is made on the strength of recent analysis by the OECD which reveals that improvements in environmental quality in recent years have resulted in positive net employment effects in the short term, moderate impacts on inflation, averaging 0.1 to 0.3% per annum, and neutral or slight positive effects on economic growth. See report by the Environmental Studies Branch of the Department of Science and the Environment on the follow-up to the OECD Environment Committee Meeting at Ministerial Level (Paris : 7-8 May, 1979) - Volume 1 : OECD Press Statements and Australian Ministerial Statements. pp.19-20.

6. See *SARUM 76 and SARUM Handbook, op.cit.*

7. For a full listing of these cases references should be made to J.M. Mula and D. MacRae, "Prospect 2000: Australia in a World Context", Environmental Studies Paper, AREA-8 presented to 150th Anniversary Conference *Prospect 2000*, West Australia Division of ANZAAS, Perth, 14-18 May 1979.

8. *Ibid.*, p.4.

9. See K.E.F. Watt, *et. al.*, 'A Simulation of the use of Energy and Land at the National Level', *Simulation*, Vol.24, No.5, May 1975.

10. The results discussed in the next two sub-sections have been documented more fully in 'Food Policies and Prospects - Insights from Global Modelling' by Howard Wagstaff in *Food Policy*, August 1979.

11. *Ibid.*, pp.161-167.

12. The Australian of 21 October 1978 carried the headlines "Food for 40 million - Scientist urges crash program to aid South East Asia" and it referred to a claim by CSIRO scientist G.R. Pierce that Australia could support 60 million people at present consumption levels without excessive risk to her agricultural stability by the year 2000. He assumed Australia's population would stabilize at 20 million by 2000.

13. B.R. Davidson, 'The Distribution of Agricultural Land in Australia', *Journal of the Australian Institute of Agricultural Science*, December, 1961.

14. Wagstaff, *op cit.*, p.160.

15. The Financial Review, 8 August, 1979 - "NZ-Aust Union - who's reluctant?"